

Glomalin

A Manageable Soil Glue

A strong glue, glomalin, is produced by a beneficial fungus that grows on plant roots. The glue comes off of the fungus and is deposited on soil particles. This process leads to build up and stabilization of aggregates.

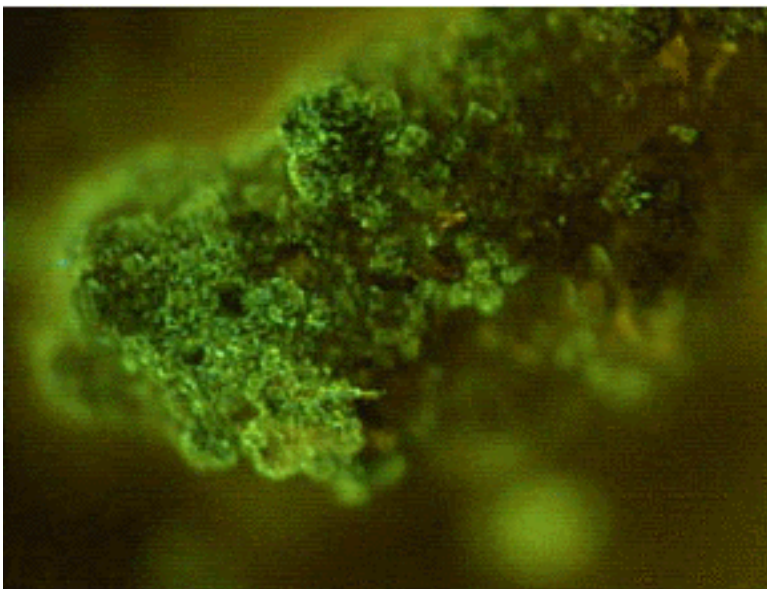


Fig. 1. Glomalin in its natural state is brown. A laboratory procedure reveals glomalin on soil aggregates as the green material shown here.

Soil aggregation is a complex process that is largely dependent upon microorganisms to provide glues that hold soil particles together. These glues are carbon-containing compounds that protect microorganisms from drying out. We are beginning to understand the importance of one group of soil fungi and the glue that is produced in large amounts by these fungi. The fungi are the **arbuscular mycorrhizal fungi (AMF)** and the glue was named **glomalin** after **Glomales** — the taxonomic order of this group of fungi.

AMF are ancient microorganisms that evolved with plants as they moved from water to land. These fungi are beneficial to plants because hyphae, hair-like projections of the fungus, explore more soil than plant roots can reach and transport phosphorus and some other nutrients to the plant. In return, plants provide carbon for growth of the fungus. We think that glomalin protects hyphae during transport of nutrients from the plant to the hyphal tip and from soil to the plant. When a hypha stops transporting nutrients, we think that glomalin comes off of the hypha and moves into soil where it attaches to minerals and organic matter (Fig. 1). The fungus is continually moving down a plant root and forming new hyphae, so an individual hypha is not as important as the whole mass of hyphae that come and go during the life of the plant. Growth of AMF occurs only when there are active roots to colonize.

Discovery of glomalin was reported in 1996¹. Two characteristics that were immediately apparent were abundant production by AMF and “toughness” of the molecule. Figure 2 shows the coating of glomalin on hyphae as revealed by the same laboratory procedure that produces the green-colored glomalin on aggregates. Preparations such as this indicated that hyphae produce amazing amounts of glomalin. Solubilization of glomalin requires immersion of hyphae or soil in a citrate solution and high heat (121 °C or 250 °F) for at least one hour² — unusual conditions that had not previously been used to study soil glues. It is necessary to solubilize glomalin to be able to study the chemistry of the molecule and to compare quantities in different soils.

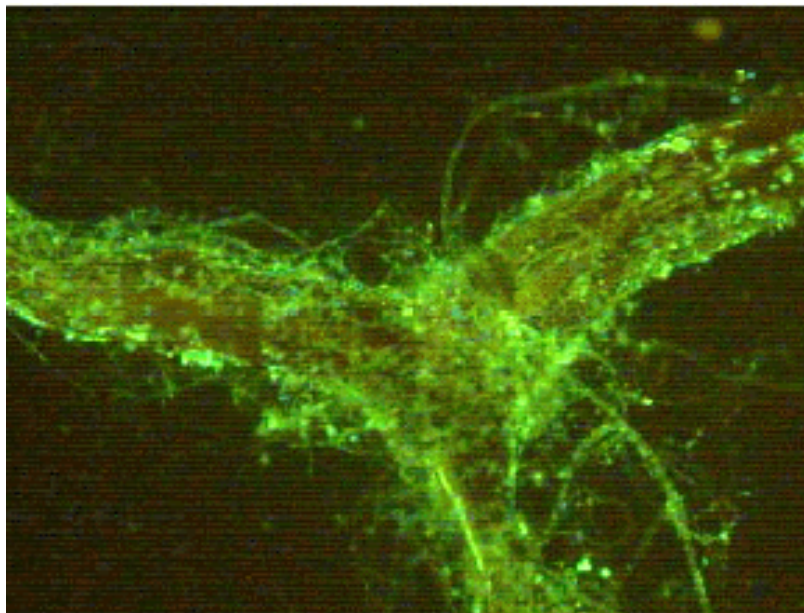


Fig. 2. An arbuscular mycorrhizal fungus colonizing a root. Hyphae are the thread-like filaments. The green coating on hyphae is glomalin.

High concentrations of glomalin were found in Mid-Atlantic states soils. We also showed that glomalin was probably a factor in aggregate stability. The next report related glomalin to aggregate stability across a number of soil types³ and indicated that management practices were important in accumulation of glomalin and aggregate stability.

Glomalin concentration and aggregate stability are related over 3 years during conversion from conventional tillage (P-T) to no tillage (N-T) corn (Fig. 3). A comparison was made with a perennial grass that grew undisturbed for 15 years as a buffer around the plots.

Increases in both stability and glomalin were seen at yearly intervals, but had not reached the levels in the undisturbed grass. Higher levels of glomalin give greater water infiltration, more permeability to air, better root development, higher microbial activity, resistance to surface sealing (crusts) and erosion (wind/water).

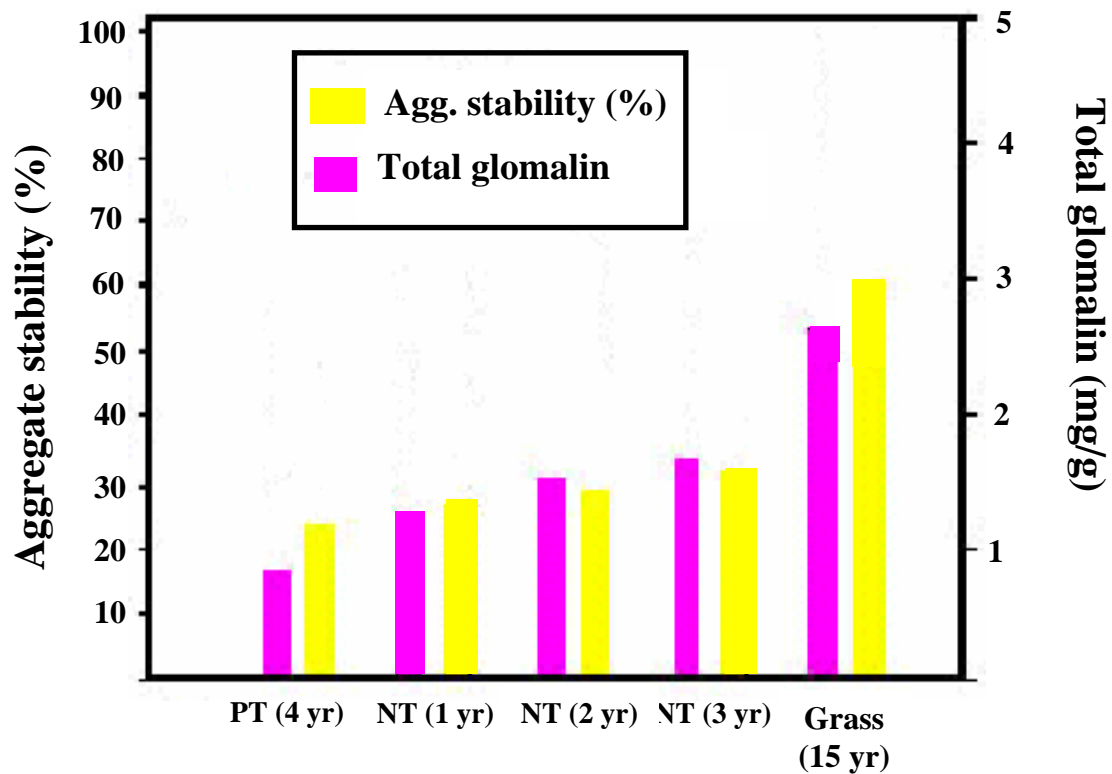


Fig. 3. Both aggregate stability and glomalin increased over three years in transition from plow-till (PT) to no-till (NT). This soil will require longer than three years in NT to approach the stability achieved by an undisturbed perennial grass.

How to increase glomalin in soils:

- Use no-till management practices to allow AMF to grow during the cropping season. Tillage disrupts the hyphal network that produces glomalin. Disruption of the hyphal network also decreases the number of spores and hyphae to start the process again on the next crop.
- Use cover crops to maintain living roots for the fungi to colonize.
- Maintain adequate phosphorus level for crops, but do not over-apply P because high levels depress the activity of these fungi.
- Be aware that there are some crops that do not associate with AMF. These plants are primarily Brassicaceae (cabbage, broccoli, cauliflower, canola). A nonmycorrhizal crop is equivalent to fallow for AMF.

Benefit of glomalin:

Increased aggregate stability which leads to better soil structure which, in turn, leads to better plant production.

References:

1. S. F. Wright, M. Franke-Snyder, J. B. Morton, and A. Upadhyaya. 1996. Time-course study and partial characterization of a protein on hyphae of arbuscular mycorrhizal fungi during active colonization of roots. *Plant and Soil* 181:193-203.
2. S. F. Wright and A. Upadhyaya. 1996. Extraction of an abundant and unusual protein from soil and comparison with hyphal protein of arbuscular mycorrhizal fungi. *Soil Science* 161:575-586.
3. S. F. Wright and A. Upadhyaya. 1998. A survey of soils for aggregate stability and glomalin, a glycoprotein produced by hyphae of arbuscular mycorrhizal fungi. *Plant and Soil* 198:97-107.

Other Publications

S. F. Wright, A. Upadhyaya, and J. S. Buyer. 1998. Comparison of N-linked oligosaccharides of glomalin from arbuscular mycorrhizal fungi and soils by capillary electrophoresis. *Soil Biology and Biochemistry* 30:1853-1857.

S. F. Wright and A. Upadhyaya. 1999. Quantification of arbuscular mycorrhizal fungi activity by the glomalin concentration on hyphal traps. *Mycorrhiza* 8:8:283-285.

Rillig, M. C., S. F. Wright, M. F. Allen and C. B. Field. 1999. Rise in carbon dioxide changes soil structure. *Nature* 400: 628.

Glossary of terms used in this brochure:

Aggregate stability - A measure of how much breakdown of aggregates occurs when dry aggregates are immersed in water and gently tumbled. Results presented indicate the percent of aggregate weight remaining after 5 minutes in water compared with the starting weight.

Arbuscular mycorrhizal fungi- a group of soil fungi that grows on plant roots. Arbuscular refers to arbuscule - a structure found in cortical cells of roots where exchange of nutrients between the plant and the fungus takes place. Mycorrhizal refers to the habitat of these fungi (mycor = fungus; rhizal = root).

Autoclave temperature - the temperature of steam under 15 psi of pressure (121 °C or 250 °F). An autoclave generally is used to sterilize solutions and instruments.

Colonization - establishment of the association between plant roots and arbuscular mycorrhizal fungi that allows the fungus to grow.

Fungi - any of a group of plants, including mildews, molds, mushrooms, rusts and toadstools, that have no leaves, flowers, or green color and reproduce by means of spores.

Glomalin - a glycoprotein with glue-like properties produced by arbuscular mycorrhizal fungi.

Glycoprotein - A protein with attached carbohydrates. This type of molecule contains both carbon and nitrogen.

Hyphae - threadlike filaments of a fungus.

Microorganism - any microscopic or ultramicroscopic animal or vegetable organism.

Molecule - the smallest particle of a compound that can exist in the free state and still retain the characteristics of the compound.

Soil stability - resistance of a soil to erosion by wind and water.

Solubilization - the process of dissolving glomalin, an insoluble chemical compound.

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